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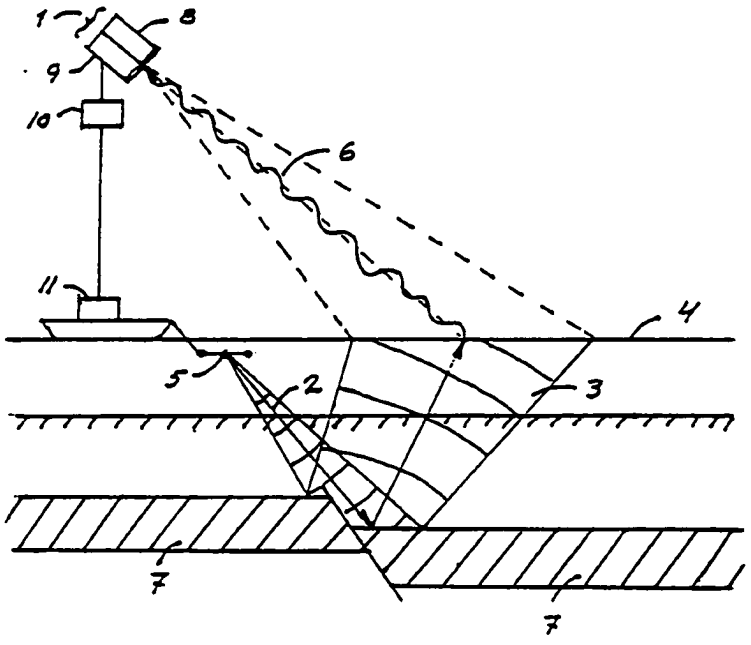
(54) Title: ELECTROOPTICAL SENSOR SYSTEM FOR MARINE SEISMIC DATA ACQUISITION



(57) Abstract

The present invention concerns a system for detecting and acquiring marine seismic data generated by conventional seismic signal sources. The system consists of an electrooptic sensor (1) and a signal processor (10). The electrooptic sensor emits light energy which when reflected from the scanned sea surface (4) is frequency shifted by movements in the water surface, created due to incoming seismic pressure waves (3). The reflected light signal is received separately from each surface part (12) by the electrooptic sensor, processed in the signal processor and recorded in a data recorder (11). This system entails that the activity of mapping underground formations at sea can be done without using seismic streamer cables.

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ELECTROOPTICAL SENSOR SYSTEM FOR MARINE SEISMIC DATA ACQUISITION

Previously known methods regarding seismic investigations for determining the occurrence of oil and gas by mapping underground rock formations at sea, are based upon collecting pressure data from sound waves generated by air guns, explosives or other similar sound sources, and which after reflections in the underground formations are sensed by a large number of hydrophones mounted in long cables or streamers and towed under the water surface behind a vessel. These hydrophone streamers are divided in sections (hydrophone groups), which sections are also referred to as channels. The seismic sound source is fired in approximately 25 m intervals, and each subsequent measurement is made in a time period of approximately 6-8 seconds. Normally, each channel is sampled using 2 or 4 ms intervals. The aquired data are recorded separately from each channel and converted to a digital format, since the subsequent processing of the recorded information is very comprehensive and is executed in a digital format.

Since large water areas are to be covered by densely spaced scan lines, these methods involve a time consuming and therefore cost demanding activity, which activity is also to a large extent dependent on outside conditions like seaway, ocean currents and ice.

The purpose of the present invention is to make possible the aquisition of conventional seismic data without using the above mentioned streamers, and thus simplifying the activity, with economic gains as a consequence.

In the following, the invention will be described further by means of the following drawing figures:

Fig. 1 illustrates the basic concept of the present invention.

Fig. 2 illustrates in a schematical manner how the position of a scanned surface part is related to a reference point (the sensor system).

From fig. 1 appears a method where the electrooptic sensor 1 is mounted in a mast in the vessel which generates the seismic

pressure waves 2 by means of seismic sound sources 5, and scans in separate surface parts 12 those water areas which are of interest for the data aquisition. These surface parts correspond to the separate hydrophone groups (channels) in the systems used to-day, which normally have an approximate length of 10-20 m. The pressure waves 3 reflected from the underground formations 7 create movements in the water surface 4. The vertical velocity component of the oscillating movement of the water surface constitutes the interesting information, and is sensed by means of the emitted light signal 6, the frequency of which will be changed in the reflection against the water surface, through Doppler shift. The light beam will be reflected not only by the water surface, but also by particles and other discontinuities in the interface layer water/air. The frequency changes of the light signal are detected in the sensor system receiver and converted to live amplitude data which are proportional to the sound pressure of the pressure waves incident on the surface parts. This information is processed further in the signal processor 10 to provide a signal format which is compatible with the signals from the hydrophone groups ordinarily used to-day. The signals are thereafter recorded in a digital format in a standardized data recorder 11.

In this manner the total cost of the electrooptical sensor system can be minimized, since investments already made regarding signal processing and data recording equipment are utilized.

The electrooptic sensor senses continuously the sea surface in surface parts, in the manner indicated in fig. 2. Each surface part corresponds to a hydrophone group (channel) in the known aquisition system. The position of each scanned surface part 12 is related to a reference point by recording the radial angle (u) and the vertical angle (v) in which the light beam is emitted and received in each measuring event.

With to-day's system based upon the use of hydrophones, also undesired signals will be recorded together with the primary signals. Such perturbations are usually constituted by larger or smaller sea waves. Since the recording of the

reflected light signal is made over a surface part, the area of this surface part can be chosen in such a manner as to avoid that these surface-generated perturbations are in phase over the scan surface. On the other hand, the seismic primary signals will impinge on the sea surface with an angle close to 90 degrees, and will therefore be recorded in phase over all of the scan surface (the surface part).

It is also possible to arrange two or more electrooptic sensors in different positions, so that the simultaneously emitted light beams impinge on and scan the scan surface part with different incidence angles. In this case the recorded data will contain information to render possible a further forward filtering and amplifying of the seismic primary signals in relation to the surface-generated perturbations.

P A T E N T C L A I M S

1. Electrooptical sensor system (1) for detecting and aquiring marine seismic data generated by conventional seismic signal sources (5),
c h a r a c t e r i z e d i n that said sensor system (1) consists of an optical transmitter (LASER) (8) which emits light energy (6) toward a water surface (4), an optical receiver (9) which detects those light signals returned by reflection in the water surface and Doppler shifted by particle movements generated in the interface layer water/air by seismic pressure waves (3) incident toward said water surface, as well as a signal processor (10) which converts the Doppler information in said light signals into electrical signals which contain data regarding the pressure variations in the seismic pressure waves.

2. System in accordance with claim 1,
c h a r a c t e r i z e d i n that said sensor system (1) is mounted in a vessel equipped with a means (5) for generating seismic pressure waves.

3. System in accordance with claim 1,
c h a r a c t e r i z e d i n that said sensor system (1) is adapted for continuously scanning the sea surface in surface parts, said surface parts corresponding one by one to a hydrophone group (channel) in to-day's aquisition systems.

4. System in accordance with claims 1 and 3,
c h a r a c t e r i z e d i n that two or more sensor systems (1) are mounted in such a manner as to scan the sea surface simultaneously in different surface parts.

5. System in accordance with claims 1 and 3,
c h a r a c t e r i z e d i n that two or more sensor systems (1) are mounted in such a manner as to scan the sea surface with different incidence angles simultaneously in the same surface parts.

6. System in accordance with claim 1, c h a r a c t e r i z e d i n that said sensor system (1) is mounted in an air vessel, or in a fixed installation at sea or on land.

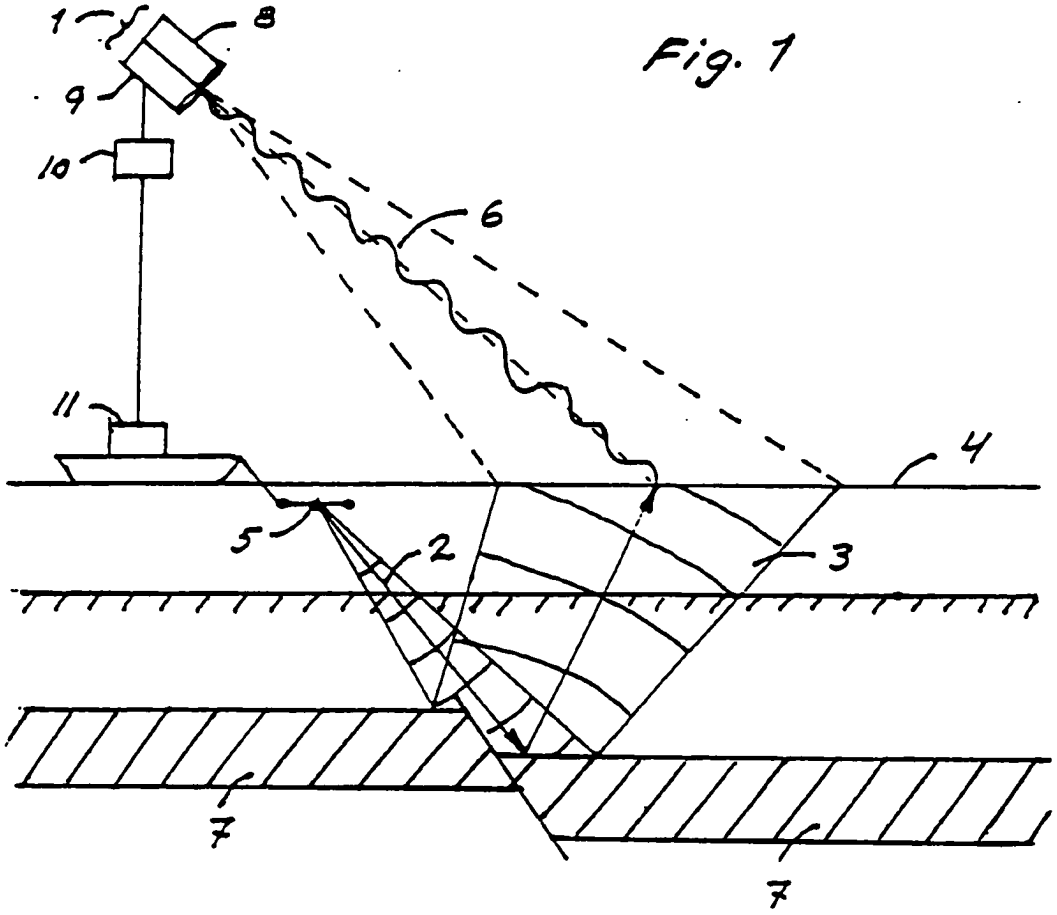

Fig. 1

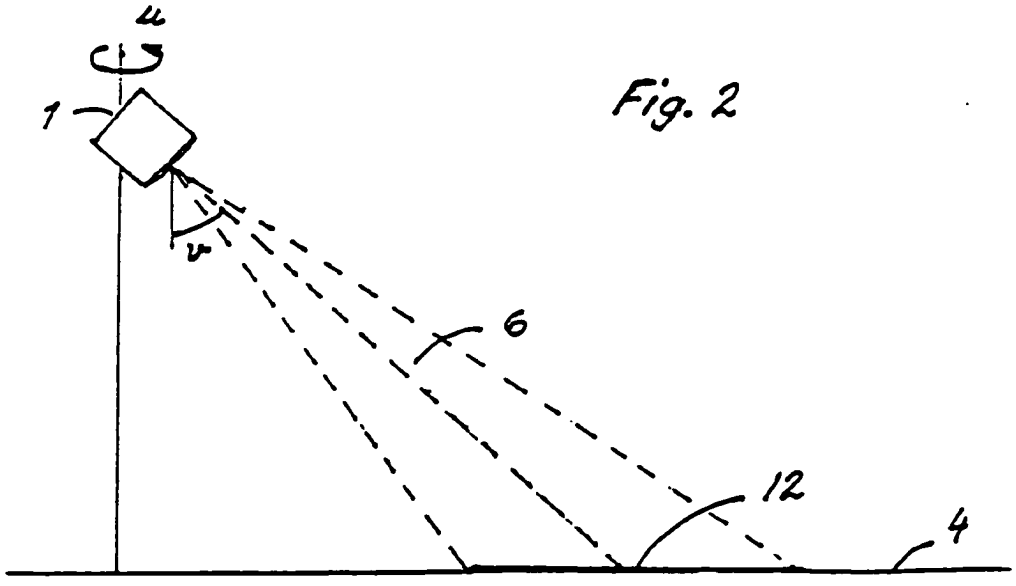

Fig. 2

INTERNATIONAL SEARCH REPORT

International Application No PCT/NO 91/00027

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: G 01 V 1/38, G 01 S 15/88, G 01 S 17/88

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	G 01 V, G 01 S

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
A	WO, A1, 8704258 (D.T. GJESSING) 16 July 1987, see page 4, line 8 - page 5, line 27; page 7, line 1 - page 9, line 15; abstract --	1-6
A	US, A, 4583095 (G. PETERSON) 15 April 1986, see column 2, line 4 - line 58 --	1-6
A	GB, A, 2063003 (INSTITUT FRANCAIS DU PETROLE) 28 May 1981, see column 1, line 25 - line 63; abstract --	1-6
A	US, A, 4787069 (C. BEAUDECEL ET AL) 22 November 1988, see abstract --	1-6

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
27th May 1991	- 03
International Searching Authority: SWEDISH PATENT OFFICE	Signature of Authorized Officer: STEFAN SVAHN

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	US, A, 4242740 (W. H. RUEHLE) 30 December 1980, see column 1, line 58 - column 2, line 7 --	1-6
A	US, A, 4569588 (Y NISHIWAKI ET AL) 11 February 1986, see column 3, line 4 - line 22 --	1-6

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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
WO-A1- 8704258	87-07-16	AU-D-	6842387	87-07-28
		EP-A-B-	0252971	88-01-20
		JP-T-	63502138	88-08-18
		US-A-	4843597	89-06-27
US-A- 4583095	86-04-15	NONE		
GB-A- 2063003	81-05-28	CA-A-	1157131	83-11-15
		FR-A-B-	2469717	81-05-22
		JP-C-	1588438	90-11-19
		JP-B-	2013275	90-04-03
		JP-A-	56093007	81-07-28
		NL-A-	8006069	81-06-01
US-A- 4787069	88-11-22	CA-A-	1267469	90-04-03
		EP-A-B-	0228932	87-07-15
		FR-A-B-	2590684	87-05-29
US-A- 4242740	80-12-30	AU-B-	526120	82-12-16
		AU-D-	4314479	79-07-19
		CA-A-	1116738	82-01-19
US-A- 4569588	86-02-11	DE-A-	3377592	88-09-08
		EP-A-B-	0092369	83-10-26
		JP-C-	1368809	87-03-11
		JP-A-	58182524	83-10-25
		JP-B-	61035495	86-08-13